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THE REQUIREMENT FOR WILD WEASEL DEFENSE SUPPRESSION ASSETS IN REDUCING AIRCRAFT ATTRITION

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

ROBERT HENRY HASELOFF, MAJOR, USAF
B.S., Texas A&M University, 1974

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The focus of this thesis is to determine if Wild Weasel assets are required during a conflict, and ascertain when they become cost effective in reducing attrition of strike aircraft. This study examines three aspects of the suppression of enemy air defense (SEAD) mission. First is the history of electronic combat. This thesis covers the history of aerial electronic combat beginning with the introduction of radar controlled antiaircraft gun and missile systems after World War II. Recent hostilities include the Flaklands conflict the Bekaa Valley debacle, and the 1986 raid on Libya by U.S. Forces. The second aspect covers the Soviet radar threat. Presentation of the Soviet threat discusses doctrine, employment of the Soviet air defense system, the capabilities and weaknesses of each Soviet radar system, and concludes with an insight to future Soviet weapons systems. The final portion of the thesis provides an analysis of fighter attrition and a cost effective break-even point. Concluding remarks discuss the validity of using Wild Weasel assets as a cost effective method of lethal defense suppression in reducing aircraft attrition.

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

THE REQUIREMENT FOR WILD WEASEL DEFENSE SUPPRESSION ASSETS IN REDUCING AIRCRAFT ATTRITION
BY MAJOR ROBERT HENRY HASELOFF, USAF.

The combat effectiveness of tactical airpower can be assured during a conflict only if attrition is maintained at minimum levels. In today's high threat environment, the Warsaw Pact nations outnumber the NATO allies in front line aircraft by a factor of 2.4 to 1 and have over 1800 surface-to-air missile launchers and 1500 search radar systems. Therefore, we must have an effective and efficient defense suppression capability to effectively accomplish the counterair mission. Effective suppression of enemy radar systems is directly associated with attrition rates of fighter aircraft operating in the vicinity of the forward edge of the battle area (FEBA). The focus of this thesis is to determine if Wild Weasel assets are required during a conflict and ascertain when they become cost effective in reducing attrition of strike aircraft.

This study examines three aspects of the suppression of enemy air defense (SEAD) mission. First is the history of electronic combat. This thesis covers the history of aerial electronic combat beginning with the introduction of radar controlled antiaircraft gun and missile systems after World

War II. Other areas discussed include the development of the first Wild Weasel aircraft during the Vietnam conflict and the lessons learned from the 1973 Arab-Israeli War. Recent hostilities include the Falklands conflict, the Bekaa Valley debacle, and the 1986 raid on Libya by U.S. forces.

The second aspect covers the Soviet radar threat. Presentation of the Soviet threat discusses doctrine, employment of the Soviet air defense system, the capabilities and weaknesses of each Soviet radar system, and concludes with an insight to future Soviet weapons systems.

The final portion of the thesis provides an analysis of fighter attrition and a cost effectiveness analysis to determine when the Wild Weasel force reaches a cost effective break even point. Concluding remarks discuss the validity of using Wild Weasel assets as a cost effective and viable method of lethal defense suppression in reducing aircraft attrition.

ACKNOWLEDGEMENTS

From the beginning, work on this thesis had the support of many people who provided valuable assistance. First, and foremost, are members of the thesis committee, who provided encouragement, motivation, and guidance throughout the period. Secondly, are the many friends who have assisted in editing the numerous drafts and producing the final product. Finally, the courteous and professional staff of the Combined Arms Research Library who always provided cheerful assistance and smiling faces.

During the initial phases of research there were many problems in defining electronic combat. In September 1987, research led to a document titled "Electronic Combat: A New Perspective" by Michael C. Naum. This paper provided a basis for building the definition of terms and a new approach to defining electronic combat terminology.

This thesis is dedicated to all people in the electronic combat field who have written articles, research reports, and theses, and especially to the memory of Michael C. Naum who was killed, 20 May 1987, on a Wild Weasel training mission. These papers provide researchers with the needed information for follow-on projects such as this.

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CHAPTER 1

INTRODUCTION

To gain air superiority and effectively accomplish close air support (CAS) and air interdiction (AI) missions, there must be an effective and efficient defense suppression capability. This defense suppression capability will decrease the attrition of both our air-to-air and air-to-ground fighter forces.[1] Recent improvements in surface-to-air defense capabilities of the Warsaw Pact nations pose a direct threat to NATO aircraft during a wartime scenario. Effective suppression of enemy radar systems is directly associated with attrition rates. As suppression effectiveness increases, attrition rates will decrease. Our defense dollars can then go to supporting fighter bombers, dual role fighters, and training the pilots for those aircraft.[2]

The inbound fighter must pass through the forward edge of the battle area (FEBA) enroute to his target without threat radar engagement. During the Vietnam conflict, many fighters would jettison their weapons to gain maneuverability and speed when they believed they were engaged by an enemy radar. Ultimately, the most important aspect of a threat radar engagement is survival of the fighter. To effectively

destroy the enemy's airfields and storage areas, the fighter must not only survive a radar engagement, but also continue to the target to deliver ordnance.[3] The safety of the fighter and accurate delivery of weapons against the enemy can be assured only if electronic combat assets effectively suppress enemy radar systems.[4]

Current stand-off capabilities in the defense suppression mission have undergone large changes during the last 10 years. The high speed antiradiation missile (HARM) is a very effective stand-off weapon. However, to effectively suppress an area, it requires a large quantity of missiles.[5] To form an air corridor, Wild Weasels can use either air-to-surface missiles in a stand-off mode or deliver cluster bombs in a direct mode against emitting radars. The direct delivery method will not only suppress the enemy's ability to engage fighters, but will also increase the attrition rate of the Weasel. Attrition rates of fighters against the current Soviet threat will reduce our capability to effectively wage war in only a few days. Reducing fighter attrition can be accomplished with an effective mix of defense suppression assets.[6]

The purpose of this research problem will be to determine if Wild Weasel aircraft are an effective component of these electronic combat assets in reducing attrition rates of strike aircraft during bombing attacks. Attrition rates concerning strike aircraft and the effectiveness rates of the

Wild Weasel aircraft will be studied. Determination of an effectiveness rate will show when the Weasel provides cost effective protection to the strike force.

ASSUMPTIONS

The following assumptions will be made during the course of the thesis:

1. It will be assumed that a 2% attrition rate will be the highest level of attrition accepted for fighters during the course of a war/conflict. This rate is derived from rates attained during the Vietnam conflict which ranged from 14% in the early portions of the war, to 1.4% at the end. Also, it will be assumed there will be missions where this rate will be higher, but the overall rate will be at or below 2%.[7]

2. Attrition rates for fighters without defense suppression assets are estimated to be between 4% and 20% by various sources. The rate used in this thesis will be 10%.

3. This thesis addresses only attrition of the strike aircraft and assumes no attrition for the Wild Weasel aircraft.

DEFINITION OF TERMS

The development of radar before World War II, surface-to-air missiles in the mid 1950's, and heat seeking missiles in the 1960's have all impacted the electronic battlefield. Most recently, jam resistant radios, microwave

datalinks, and satellite relays have added to the confusion when defining electronic combat.[9]

The common thread that ties these technologically advanced systems together is the electromagnetic spectrum. Currently, the effective use of these new systems depends on the ability to maintain control of that portion of the electromagnetic spectrum in which each system operates.

The electromagnetic spectrum is defined in JCS Publication Number 1 as the range of frequencies of electromagnetic radiations from zero to infinity. This spectrum is divided into 26 alphabetically designated bands. This thesis will focus on the bands from C to J (frequencies from 500 megaherz to 20,000 megaherz). This includes the acquisition, target tracking, and missile guidance radars of all mobile threats considered in this paper.[10]

The understanding of electronic combat is based on definitions which accurately describe the role of electronic combat on the modern battlefield. The term "electronic combat" is relatively new. However, terms used to describe each element of electronic combat have been in use for some time. These technical definitions describe how the various electronic combat elements operate within the electromagnetic spectrum.

The inter-relationships of the three subelements of electronic combat can best be shown in Figure 1-1.

ELECTRONIC COMBAT

ELECTRONIC WARFARE	C^3CM	SEAD
*ESM -DETECT -IDENTIFY -LOCATE	*COUNTER C^3 *C^3 PROTECTION	*DISRUPTION *DESTRUCTION
*ECCM -ANTI-ACTIVE -ANTI-PASSIVE		
*ECM -DECEPTION -JAMMING		

FIGURE 1-1

Electronic Combat (EC) is the action taken in support of military operations against the enemy's electromagnetic capabilities. It involves three elements of operation; electronic warfare (EW); command, control, and communications countermeasures (C^3CM); and suppression of enemy air defenses (SEAD).[11] Electronic warfare is military action taken to deny the enemy's use of the electromagnetic spectrum, and actions that retain the friendly use of that spectrum. C^3CM is the action taken to deny information to the enemy and to protect friendly C^3 capabilities. SEAD is the action taken to neutralize, destroy, or temporarily degrade hostile air defense systems in a specified area by

physical and/or electronic attack.[12]

The Wild Weasel aircraft is designed to detect, identify, and locate enemy radar systems. After the radar is located, the Wild Weasel uses an assortment of missiles and bombs to physically destroy a threat radar. Several subelements of electronic warfare (EW) are used to accomplish the destructive portion of a SEAD mission. Initially, all elements of ESM will be used in detecting, identifying, and locating the threat radar. Secondly, after locating the threat radar, the Wild Weasel will use deception and self protection jamming from the ECM sub-element of electronic warfare (EW) to complete the destruction of the radar system.

Suppression of enemy air defenses (SEAD) refers specifically to the disruption or destruction of air defense radar systems, and involves the physical action taken to destroy or disrupt the radar system itself. The methods used to locate and attack the threat radar, however, include the primary subelements of EW.[13]

Many authors use the term electronic warfare in an all-encompassing form when, in effect, there is a specific term which applies to that portion of the electronic combat arena. Therefore, the relationship of the terms can become somewhat confusing. For the scope of this thesis, the term electronic combat will denote the broad aspect of the term including all three subelements.

Many civilian writers reference electronic combat and place it on a level with electronic warfare. The incorrect use of these terms can only lead to further confusion. The writer should always describe the exact characteristic of electronic combat using the correct terms which will insure understanding by the reader. One writer referred to the destructive capability of SEAD as a lethal electronic countermeasure (ECM), a subelement of electronic warfare.[14]

The concept of electronic combat aircraft is not unique to the United States. The Germans have approved full production of an electronic combat and reconnaissance (ECR) aircraft which will be capable of carrying the air launched antiradiation missile (ALARM) developed by Great Britain.[15] Also, according to several sources, the Israelis are continuing to update their version of a "Special Mission" fighter, which was successful during the Bekaa Valley debacle.[16] There is currently no Soviet equivalent of the Air Forces' Wild Weasel aircraft. However, the SU-24 Fitter has acquired an intensive array of antennas and may perform the mission in the future.[17]

LIMITATIONS

The main focus of this thesis will be to determine how effective the Wild Weasel must be in reducing attrition before becoming cost effective. Due to classification problems, this thesis will not attempt to determine combat

capabilities of the Wild Weasel in a lethal defense suppression role. Additionally, the benefits of outside jamming by both the EF-111 (Raven) or the EC-130 (Compass Call) aircraft will not be considered in this study. Normally, EC assets work together in the battlefield and provide a synergistic effect against threat emitters. However, this effect is immeasurable without access to special test equipment and is beyond the scope of this study.

The disruption aspect of SEAD will not be addressed in this thesis due to the limited time available and many intangible factors involved. Additionally, the limited cost analysis portion of this thesis will address only stand-off techniques using antiradiation missiles by the Wild Weasels. Finally, this study will not look at the capabilities of Army artillery to suppress enemy surface-to-air threats in or near the FEBA.[18]

METHODS AND PROCEDURES

This study will investigate the effects of attrition rates on strike fighters and the effectiveness of using stand-off weapons by the F-4G Wild Weasel aircraft in the defense suppression role. This thesis will set forth a step by step approach to determine if Wild Weasel aircraft are required in a lethal defense suppression role and at what point these assets become cost effective.

Chapter Two presents a historical perspective on electronic combat beginning with the development of radar controlled antiaircraft artillery. Discussion will include lessons learned from hunter-killer team employment in Vietnam, the use of combined electronic assets by the Israelis in the Bekaa Valley, and other conflicts where the use of electronic combat was important.

Chapter Three discusses Soviet air defense doctrine and command and control procedures. Additionally, a review of current Soviet mobile threat systems will include the SA-6/11, SA-8, SA-10, and the ZSU-23-4. Finally, an overview of Soviet air defense weaknesses and emerging trends will be presented.

The first portion of Chapter Four will determine attrition rates for fighter aircraft in the FEBA area, both with and without the benefit of lethal defense suppression assets. A base of 1,000 strike aircraft and 40 Wild Weasel aircraft will be used during each analysis. Chapter Four then compares attrition rates, analyses cost effectiveness, and determines how effective the Wild Weasel assets must be to reach a cost effective break even point.

A cost effectiveness analysis will determine if the benefits of defense suppression assets in the forward battle area are economical. These benefits will be compared with the same defense dollars spent toward fighter aircraft as replacements to overcome the expected attrition rates without

defense suppression assets.

These results will then be used to determine an approximate effectiveness rate required of the Wild Weasel aircraft in combat to maintain fighter attrition rates at an acceptable level.

Chapter Five will summarize previous data and present conclusions to the reader.

REVIEW OF LITERATURE

Many authors have written informative electronic combat articles, but have used terms in the wrong context or interchangeably. In one case the writer actually describes the SEAD mission as a lethal electronic countermeasure.[19] The reader must understand that electronic warfare subelements are only used in the detection and location of an enemy radar. SEAD is the actual destruction or suppression of enemy defenses, and there is no relation to ECM other than that used by the Wild Weasel for self protection.

The following references deserve comment:

"Development Planning for Defense Suppression" (U) by Stephen H. Holliday, appeared in a special issue of the Journal of Defense Research in 1978. It contains valuable information on the determination of effectiveness rates for several different types of defense suppression elements. This document is classified secret, however, no classified portions were cited in the thesis.

Soviet Radiocombat by David A. Chizum describes the basic doctrine of Soviet electronic warfare from the use of jammers to communications security. The best portion of this book is the bibliography and definition section. The focus is on Soviet electronic combat terms and their western equivalent. These sections comprise almost half the book and give the reader many references for future use.

The books, Electronic Warfare; From the Battle of Tsushima to the Falklands and Lebanon Conflicts and Instruments of Darkness; The History of Electronic Warfare provide the reader with an indepth review of electronic combat from the beginning to the recent conflict in Lebanon.

Weapons and Tactics of the Soviet Army by David C. Isby, includes an entire chapter on Soviet air defense. In this chapter, Mr. Isby discusses the principles of Soviet air defense doctrine, weapons capabilities, tactical framework, and employment of each tactical air defense system in the Soviet inventory. Especially credible are portions of the text covering apparent weaknesses in the Soviet organization of air defense units and air defense systems.

"Wild Weasel Penetration Model" is a research study accomplished by Kenneth Anderson and Ronald Nenner at the Air Force Institute of Technology in 1982. This paper provided a good background in determining attrition rates and the effectiveness of Wild Weasel operations.

"An Aircraft Attrition Analysis for F-4G Wild Weasel Employment in Central European Scenarios of 1982 and 1986" (U), by Carrol Johnson, provided the reader with an excellent background on determining attrition rates of Wild Weasel aircraft operating in the FEBA. The paper looked at several direct bombing methods and other weapons used by the Wild Weasel in the defense suppression role. The study then derives attrition values for each method of delivery. This document is classified secret, however, no classified portions were cited in this thesis.

ENDNOTES

CHAPTER ONE

[1]William R. Langridge, "Analytical Requirements for Defense-Suppression Effects on CAS/BFI Survivability" Journal of Defense Research Special Issue 78-2, (August 1978): 165. (This article was de-classified on 31 December 1985. No previously classified portions of this article were cited); Richard A. Rash, "Electronic Combat--Making the Other Guy Die for His Country" (Research Report, Maxwell AFB, AL, USAF Air War College, March 1983): 64.

[2]William R. Taylor, "Concept for a Loitering Attack Weapon to Enhance Suppression of Enemy Air Defenses" (Research Report, Maxwell AFB, AL, USAF Air Command and Staff College, May 1986): 1.

[3]Ibid., 8.

[4]Rash: 64.

[5]Ibid., 62.

[6]"Lessons of the South Atlantic War," Defense and Foreign Affairs, 10, (September 1982): 3, 27.

[7]Stephen H. Holliday, "Development Planning for Defense Suppression"(U) Journal of Defense Research, Special Issue 78-2, (August 1978): 9 (Secret) (No classified portions of this document were cited); Taylor: 5.

[8]Kenneth C. Anderson and Ronald B. Nenner, "A Wild Weasel Penetration Model" (Masters Thesis, Wright-Patterson AFB, OH, Air Force Institute of Technology, March 1982): 110.

[9]Seymour J. Deitchman, "Weapons, Platforms, and the New Armed Services," Issues in Science and Technology, 1, (Spring 1985): 85.

[10]Department of Defense, JCS Publication 1, (Washington, 1986): 127.

[11]Richard M. Atchison, "Electronic Combat," Journal of Electronic Defense, 10, (April 1987): 67.

[12]United States Air Force, AFM 2-8, Electronic Combat (EC) Operations, (Washington, United States Air Force, 1987): 3-6.

[13]Michael C. Naum, "Electronic Combat: A New Perspective" (Research Report, Maxwell AFB, AL, USAF Air Command and Staff College, May 1986): 27.

[14]Kenneth Krech, "HARMing the Prowler," Defense Electronics, 18, (October 1986): 165.

[15]"German ECR Tornado Program Getting Go-Ahead," Journal of Electronic Defense, 9, (June 1986): 37-38.

[16]Bill Sweetman, "EW Dedicated Aircraft: A Continuing Requirement," International Defense Review, 12, Supplement 2, (December 1985): 21-24.

[17]Ibid.

[18]Rash: 1.

[19]Kretch: 165.

CHAPTER 2

HISTORY

One lesson learned by both the United States and the Soviet Union during World War II was the importance of an effective and self-contained radar controlled antiaircraft artillery system. The concept married a small and mobile radar with the actual gun battery to detect aircraft and direct gun fire toward the inbound threat.[1]

Radar integration improved antiaircraft artillery accuracy many times over. This provided an effective and efficient concentration of fire power. This improved lethality, and forced fighters and bombers to attack from higher altitudes to stay above the maximum effective range of the antiaircraft guns.[2]

An effective countermeasure used during the Korean War included TB-25J "Ferrets." These modified Mitchell bombers performed radar suppression duties while leading formations of B-26 Invaders.[3]

The Korean War experience demonstrated how electronic combat could cut losses of attacking aircraft. Following the conflict, all major powers made great strides in producing new types of equipment for bomber protection. This allowed

aircraft to enter enemy airspace without detection by threat radar and ultimately prevented engagement by the radar guided weapons systems.[4]

Both Soviet Bloc and Western nations used World War II era developments in radar and missiles to form a formidable antiaircraft weapon. The Germans had studied the concept of surface-to-air missiles (SAMs) as early as 1944, but the Soviet Union was the first to use it against an enemy aircraft. During a reconnaissance flight on 1 May 1960, the Soviet Union fired upon, and downed, the U-2 aircraft piloted by Francis Gary Powers.[5]

The Soviets developed the surface-to-air missile system to counter the medium altitude penetration tactics used by the United States. A tactic designed as a countermeasure to the effective use of radar guided antiaircraft artillery.[6]

Vietnam

On 24 July 1965, during a raid over North Vietnam, a Soviet built SA-2 surface-to-air missile shot down an American McDonnell-Douglas F-4 Phantom. This was not the first aircraft shot down in Vietnam, nor the first time an American aircraft had been destroyed by Soviet missiles. It was, however, the first appearance of Soviet built surface-to-air missiles in Southeast Asia. This introduction into North Vietnam exposed the American fighters to a new and

deadly threat where they had previously enjoyed air supremacy.[7] Top level meetings in the United States determined the only way of dealing with the new threat was to develop airborne electronic combat systems. A new electronic countermeasure system was designed to neutralize the guidance radar of surface to air missiles.[8]

While waiting for stateside industries to develop an appropriate electronic countermeasure, the only chance of survival for the fighter pilot and his aircraft was to evade the missile using violent maneuvers. Exploiting the weak points of the SA-2 system, the pilots developed a maneuver which consisted of diving toward the surface-to-air missile site after launch. They would then execute a properly timed vertical rolling maneuver which would overshoot the missile from the fighter's flight path and unlock the guidance system. While this tactic was usually effective, it did not always work. Clouds would sometimes block the pilot's view of the missiles as they were launched, thus preventing completion of the maneuver. The United States lost about 160 aircraft by the end of 1972, the majority due to the SA-2.[9]

Although the SA-2 had a probability of kill (Pk) of only 10 percent, the rising losses due to this missile were mounting. The United States Air Force and Navy decided to resurrect the idea of using radar busters similar to those used during World War II. During Operation Market Garden, P-47s used radar homing devices to attack the antiaircraft

artillery sites along the coast of Holland and France.[10] The choice fell upon two aircraft, the F-100F Super Saber or the F-105F Thunderchief. Both aircraft had two seats and offered adequate payload and performance. The F-100F was chosen and conversion of seven aircraft began immediately for the "Top Secret" mission of radar detection and location.[11]

When airborne, the F-100F would join forces with the F105D Thunderchief and form a hunter-killer team known as "Iron Hand." This typical team had a single F-100F Wild Weasel hunter, supported by a flight of three F-105s, known as the killers. The Wild Weasel would identify, locate, and mark the enemy radar site for an attack by the killers. Additionally, the hunter would suppress the radar site with Shrike antiradiation missiles, while the killers were inbound to the target. This would prevent the threat radar from detecting the killer aircraft and insure their survival.[12]

However, the F-100F was not compatible with the faster F105D Thunderchief aircraft, and only two of the original seven F-100 aircraft remained in service after six months. The F-105F replaced the F-100s in the summer of 1966. In addition to being compatible with other F-105s, the new Wild Weasel also carried the AGM-45 and AGM-78 antiradiation missiles and a self-protection jamming pod.[13]

During the 1972 Linebacker I operations, the SA-2 brought down 11 B-52 aircraft. Tactics were modified. F-105G Wild Weasels and F-4C Phantoms would deploy low, in

hunter-killer teams, to protect the B-52s. The result was a sharp decline in losses. In fact, once the hunter-killer teams appeared in their sector, the North Vietnamese radar operators would shut down their radar to protect themselves.[14]

With the success of the Wild Weasels against the SA-2 missile systems in 1966, the North Vietnamese increased the number of radar controlled guns to almost 10,000 total. The following year, most aircraft losses were due to antiaircraft fire rather than surface-to-air missiles.[15]

A deception technique called "trap" was used by the North Vietnamese radar controllers. The North Vietnamese would turn on simple transmitters which simulated the sound made by the SA-2, causing the Wild Weasel aircraft to launch their antiradiation missiles against the decoy signal before reaching the target area. Before Linebacker II operations, this left the B-52s vulnerable to surface-to-air missile fire for the remainder of the flight.[16]

With an increased emphasis on electronic countermeasures, the B-52s were provided with the newest equipment. As a result, during Linebacker II, there was a loss of only 15 aircraft during a total of 700 sorties. This equals a 2.1% loss rate when compared to sorties, and a 1.5% probability of kill (Pk) when compared to the estimated 1000 missiles fired against the aircraft. Undoubtedly, electronic countermeasures contributed to the decrease in losses,

compared to initial phases of the war, when aircraft attrition rates were nearly 14 percent.[17]

The concept of Wild Weasel operations has traditionally relied on hunter-killer teams. A critical factor in this team operation is the effective and reliable transfer of information on the relative position of the threat. An additional concern is tactics to be used in the destruction of that threat. Especially since this would be the last war which targeted only stationary or fixed radar sites, as the Soviets would introduce their newly designed mobile threats within a few years.[18]

The Arab-Israeli Wars

The 1967 war between Israel and Egypt provided little on the electronic combat front. It did, however, reinforce lessons learned from past battles on the importance of air superiority. The 1967 Israeli attack saw Arab losses of over 300 aircraft on the ground and the destruction of 23 radar sites.[19] Following this battle, the Egyptian air defenses were reorganized to face the Israeli threat. Using lessons learned from Vietnam, the Soviet advisors provided the Egyptians with an integrated air defense system. Included were improved SA-2 missiles and the recently introduced SA-3. Mobile threats included the SA-6 missile system and ZSU-23-4, an automatic radar guided antiaircraft artillery gun. The concept of a radar controlled gun had been taken

one step further by placing the system on a tracked chassis to provide mobility. The missile and antiaircraft defense on the west bank of the Suez Canal now provided an integrated and mutually protective system for the Egyptian forces.[20]

Following the 1967 war, the Israelis did not react to the Arab build up and increased capability. Several faulty conclusions from prior conflicts led to the conscious decision not to respond to the Egyptian threat. The Israeli's first faulty conclusion was electronic combat systems were generally too heavy for their fighters and not essential to their ground forces. In addition, total success in air superiority and small armor concentrations led to a complacency which was to prove nearly fatal to the Israeli forces.[21]

When the Israeli Defense Forces tried to destroy bridges placed across the Suez Canal by the Egyptians in 1973, the Israeli air forces met a dense umbrella of protection provided by the new Egyptian air defense system. The result was a major loss of all types of aircraft including Phantoms, Skyhawks, and the Super Mystere fighter bombers. Even when the fighters attempted to go below the engagement altitude of the missiles, they were engaged by antiaircraft artillery systems and the newly acquired SA-7 shoulder fired, infrared missile. This further increased their losses and proved the importance of electronic combat on the battlefield.[22]

In the second week of the war the Israelis received an emergency shipment of ALQ-101 and ALQ-119 jamming pods. Additionally, the Israelis changed their tactics. The tide was turned and the Israeli Air Force regained air superiority.[23]

To gain control of the East bank, the Israelis determined that destruction, or at least neutralization, of the enemy air defense systems was paramount. To accomplish this goal they could either attack by air, resulting in a costly battle of attrition, or use a combined arms offensive on the surface-to-air missile sites.

On 16 October, M-48 tanks were ferried across the Suez Canal and refueled. Each tank then proceeded to destroy a specific surface-to-air missile site. Within two hours, five active surface-to-air missile sites were completely destroyed. The Israeli fighters and bombers then bombed the remaining SAM sites and Egyptian tank forces.[24]

In the following days, tanks and artillery destroyed additional defense systems. In several instances, Egyptian surface-to-air missile crews even resorted to firing missiles at the incoming armor forces--to no avail. In the end, the Israeli ground and air forces had destroyed over 75 percent of the Egyptian surface-to-air missile sites. Withdrawal of the remaining missiles from the area left the skies free for the Israeli Air Forces to attack at will.[25]

Falklands

Lessons learned from the Falklands conflict generally showed no new aspects in the electronic combat field. Nonetheless, several old trends re-emerged.

The first trend was the occurrence of heavy losses of aircraft on both sides during attacks on well-defended targets. One reason for the high losses was attacks which focused only on the target rather than on the defenses which protected the target.

Second, the electronic combat capabilities of both Britain and Argentina were inadequate as well as outdated. The British Sea Harrier's jamming pods were not tailored to the Argentinean radar threat. In addition, Argentinean fighters had no electronic countermeasures capability, resulting in the loss of over one-third of their aircraft.[26]

During the conflict, the British attempted to destroy the Argentinean search radar used to locate British naval forces and pass updated guidance commands to Exocet missiles launched against British forces. The attack consisted of two Vulcan bombers carrying four AGM-45 antiradiation missiles. The Vulcans, stationed on Ascension Island, were required to refuel inflight several times. Refuelings were performed both enroute to the target and during the recovery to their home base. The first attempt to destroy the radar was never completed due to air refueling problems. The outcome of the second attempt is still uncertain, and the last attempt was

inconclusive since the Argentineans would switch off the radar each time the Vulcan aircraft approached for the attack. This technique of emission control denied the missile the signals required to guide itself to the radar.[27]

During a September 1982 conference in London, several lessons learned were discussed. A summary of these lessons are listed below:

-The lack of airborne early warning radar was critical to both sides.

-The need for electronic countermeasures for both ships and aircraft was proven beyond a doubt.

-The proliferation of Western-built weapons makes it likely that future conflicts will see engagements by these systems rather than those of the Eastern Bloc countries and the Soviet Union.

-Aircraft which can deliver their weapons from a stand-off position are more likely to survive and be effective than those which enter the systems engagement area.[28]

BEKAA VALLEY

On 6 June 1982, Israeli armed forces launched their long expected attack against the Palestinian stronghold in southern Lebanon. The objective was to create a 30 mile wide buffer zone along the Israeli-Lebanese border to prevent Palestinians from attacking Israel.[29]

This was the first conflict which, from the beginning, concentrated on the use of electronic combat as the basis of the attack. There were no secret weapons used by Israeli forces. Instead, it was the employment method which made the Israeli incursion so effective against the Soviet built systems.

The lessons learned during the 1973 war, when the United States had supplied the Israelis with electronic countermeasure pods, were not forgotten. Rather, the Israelis expanded upon their new attitude toward electronic combat exhibited in late 1973. Just one month after the Arab-Israeli War, the Israelis issued a statement of requirement for the design and production of Remotely Piloted Vehicles (RPV). The products that followed were the Mastif I, capable of carrying a large payload for over six hours and one hundred kilometers. Also integrated into the lethal flying arsenal of the Israeli forces were the Scout and Teledyne Ryan RPVs.[30]

In addition to the RPV program, the Israelis also placed emphasis on converting four Boeing 707s into airborne early warning aircraft. These aircraft, equipped with sophisticated countermeasures and counter countermeasures were used as both command and control and stand-off jamming platforms. Another import- ıt aspect of the Israeli electronic combat fighting capability was the development of a surface-to-surface missile designed to home on emissions

from air defense radars. This electronic combat capability was effectively used during the attack on Syria, allowing the fighters to destroy virtually all of the surface-to-air missile systems[31]

The following synopsis of tactics used by the Israeli forces in the Bekaa valley, printed in Business Week following the attack, gives the reader some concept of how these forces were integrated:

> Remotely piloted vehicles flew into the Bekaa Valley, beaming signals that fooled the Syrians into believing the tiny plastic craft were Israeli jets. The Syrians turned on surface-to-air radars, allowing the RPVs to "fingerprint" the radars. These data were relayed to an E-2C command plane so jammers on Israeli planes could be set to the right frequencies. As Israeli aircraft neared, the E-2C called for an artillery barrage to harass ground crews and rockets to dispense aluminum chaff that prevented the radars from locking on the attacking planes. F-4 Phantom jets outfitted with Wild Weasel jammers and missile-diverting flares fired missiles that home-in on radar signals or on reflected light from the RPVs laser target designators. Without their radar, the SAM launchers were "blind" and could be destroyed by conventional bombs dropped from F-16s.[32]

The battle in the air made use of several electronic combat capabilities. These include the use of deception jamming from fully automatic jamming pods, expendable countermeasures to divert electronically guided missiles, and flares to divert the infrared heat seeking missiles. The use of the most current radar warning receivers also allowed the pilots to accomplish their mission without fear, and warned them immediately if they were engaged by enemy radar.[33]

Syria's Soviet supplied aircraft were not furnished with updated radar warning receivers and had limited jamming capability for self protection. This resulted in a catastrophic loss of Syrian aircraft. The Israelis affirmed that they had shot down 79 aircraft and destroyed 95 percent of all Syrian SA-2, SA-3, and SA-6 batteries while sustaining only one aircraft loss.[34]

The center planning point of the Israeli attack was the use of the RPV. RPVs suppressed and deceived the enemy air defense systems and aided in establishment of air supremacy. These small RPVs, built of fiberglass, were almost invisible to enemy radar systems and provided reconnaissance information to the Israeli command centers. In addition, some RPVs had radar reflectors to simulate incoming aircraft and feigned attacks from different directions. Others functioned as electronic intelligence platforms. Finally, some had laser designators which were used to guide laser bombs onto their targets.[35]

In general, the battle of Bekaa Valley proved the importance of electronic combat assets, and when used in a controlled and integrated fashion, will provide the attacker with a force hard to defeat.

LIBYA RAID

The exchange of fire between the U.S. Navy and Libyan Forces began in January 1986 following the December 1985

massacres in the Rome and Vienna Airports. Phase I of the Operations in the Vicinity of Libya (OVL) began in late January. It was characterized by extensive Naval task force preparation but included little action. Only one major incident occurred during Phase I involving two Mig 25 Foxbats. Most pilots endured long hours of combat air patrol (CAP), heavy alert posture, and unusual working hours without as much as a radar contact.[36]

Phase II of OVL, from 12-15 February 1986, provided nearly all Naval pilots the opportunity to perform intercepts on Libyan Migs. There were approximately 160 encounters during the four day period. Naval pilots dominated the encounters and gained the offensive on virtually every intercept.[37]

Phase III of OVL, called the "Freedom of Navigation Operations," began on Monday the 24th of March 1986. This phase followed an announcement of the intent to hold the exercise. Initially, three units of the Surface Action Group (SAG) crossed the critical 32 degree 30 minute parallel which led to the first reaction from Libyan Forces.[38]

The Libyans launched two SA-5 (Gammon) surface-to-air missiles against a flight of F/A-18 Hornets on combat air patrol (CAP) from the carrier USS Coral Sea. A few hours later, the Libyans fired at least three SA-5 missiles and one SA-2 (Guideline) missile. All missiles missed their target. This was due to the effects of electronic countermeasures

undertaken by the Naval units and the large distance from the missile site to the target when the missiles were fired.[39]

Retaliation for the missile firings came in the form of a dedicated SEAD mission. A-7E Corsair II aircraft from the carrier USS Saratoga launched AGM-88 HARMs (High Speed Antiradiation Missiles) against the SA-5 site located near Sirte. About four hours later, a second HARM attack followed on the same site. After the second attack, the Libyan air defense site was no longer a viable threat. Over 1500 day and night sorties were then flown as close as 25 nautical miles from the coast of Libya without fear of reprisal. Phase III was complete 75 hours later on 26 March 1986.[40]

Unaffected by his clash with the Navy in phase III of OVL, Qaddafi sponsored the bombing of a discotheque in Berlin on 5 April 1986. This terrorist bombing included direct injury to off-duty American servicemen, and initiated Phase IV of OVL.[41]

In the U.S., preparation for operation El Dorado Canyon began. A target list was developed which included only targets directly related to Qaddafi's terrorism program.[42] Planners concluded the attack would take place under the cover of darkness. This would reduce the possibility of civilian injury, lessen the risk to U.S. pilots from antiaircraft weapons, and increase the element of surprise against the Libyan forces. Some observers feel that one reason for not striking during the day was to avoid an

all-out electronic battle. A daytime battle would reveal many electronic secrets on a relatively low priority target.[43]

The raid on Libya in the early hours of 15 April 1986 used only 25 bombers for five separate targets. Most people, however, were stunned to learn there were approximately 70 support aircraft during the raid. Of these, almost 25 were dedicated electronic combat aircraft.[44] Lessons learned, concerning electronic combat in the early phases of OVL and by previous Israeli experience, were put into use. The force structure of the electronic combat aircraft included five EF-111A jamming aircraft, six A-7E attack aircraft with HARM and Shrike antiradiation missiles, six F/A-18 aircraft armed with Shrike missiles, four E-2C command and control and ESSM aircraft, and several EA-6B electronic combat and jamming aircraft.[45]

The attack on military targets in Tripoli provided the first opportunity for U.S. air forces to apply many new technologies and tactics incorporated since the end of the Vietnam War.[46] The attack began at 0154 Tripoli time. All electronic combat aircraft climbed from their low level ingress altitude and allowed the Libyan radar to target these aircraft. This deliberate targeting allowed the A-7 and F/A-18 defense suppression aircraft to detect, locate and neutralize the threat radars with a volley of almost 50 antiradiation missiles. At the same time, EF-111As and

EA-6Bs began jamming and confusing enemy defenses.[47]

At 0200, the simultaneous attack by A-6E and F-111F strike aircraft began. Less than 12 minutes later, all aircraft were over water and outbound from the target. The Libyans fired large numbers of SAMs during the raid, but only created a sensational effect in the night sky. None of the missiles guided effectively.[48]

In the days following the attack, military planners felt most high technology systems performed as designed. Electronic combat systems, including the EF-111A in its first combat mission, proved to be highly successful, and the suppression of surface-to-air missiles was instrumental in reducing aircraft attrition.[49] Defense suppression by both the Air Force and Navy was unprecedented. Without it, the force would undoubtedly have lost more than the single aircraft which did not return.[50]

The attack on Libya supported many lessons concerning electronic combat for the U.S. military. Additionally, the Soviet Union and teams of Warsaw Pact special electronic experts used the attack to study U.S. jamming and deception techniques employed during the attack--an obvious consideration for future actions.[51]

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CHAPTER TWO

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CHAPTER 3

SOVIET AIR DEFENSE EVOLUTION

The use of the airplane in World War I, and its follow on development, provided the requirement to develop an effective air defense system for the Soviet Union. The Soviets responded to the new threat with the weapons at hand, machine guns and artillery.[1]

For these weapons to be effective, the Soviets developed a system of observers and reconnaissance posts in the battle area. These posts provided early warning and passed inbound aircraft information to the fire control centers. Once detected, it then became the duty of the machine gun operator or artillery control officer to transition from a surface role to an air defense role. The fact that there were no sights mounted on the weapon for use against an airborne target added to the difficulty of hitting small objects with a bulky weapon. Initially, these antiaircraft systems may not have destroyed many aircraft, but these gunners probably deterred the accurate delivery of ordnance by the pilots. This then accomplished one portion of the basic air defense mission.[2]

During World War II, the Soviets accomplished much to improve on weaknesses in antiaircraft artillery. However, by the time they acquired sufficient antiaircraft weapons and personnel to accomplish the mission, the Soviet Air Force was capable of handling the Luftwaffe air threat. This led the Soviets to use their recently acquired air defense weapons in artillery and antitank roles. Also, it increased the split between antiaircraft defense supporters and tactical airpower supporters on exactly how to perform defense of the Fatherland.[3]

In the closing days of World War II, the Soviet Army's drive into Germany uncovered many industrial plants and research facilities. These facilities contained a wealth of technology which was later transported to the Soviet Union. The facilities included the German rocket research center at Peenemunde and the radar and missile guidance facility at Wurzburg. The knowledge gained from these two programs alone gave the Soviets the lead in development of a missile air defense system. Although technological gains placed the Soviets in an excellent position, problems in missile technology would delay deployment of a surface-to-air missile until the early 1950's.[4]

Lessons learned in the Korean conflict led to the replacement of heavy antiaircraft guns with new surface-to-air missiles. It was not until April 1965, however, that the Soviets supplied SA-2 surface-to-air missile systems to

the North Vietnamese. At the end of 1965, 60 SA-2 sites were located around the Hanoi-Haiphong area. This more than doubled to 152 sites by the end of 1966. This mix of surface-to-air missiles with antiaircraft guns proved to be a valid concept in Soviet doctrine. It was not until the last major effort, during December 1972, that the North Vietnamese air defenses were overcome and unable to handle the massive effort from the United States air forces. The command, control, and radar networks were overloaded during the attacks by the U.S. Forces. This led to the defeat of over half of the air defense systems.[5]

A vast overlapping air defense network was being developed by the Soviet Union and included the SA-2, SA-3, and SA-4. However, the introduction of the first mobile surface-to-air missile system was not accomplished until 1967. Additionally, this system was not employed in combat until 1973 in the Arab-Israeli war. This new system was to usher in the newest change to Soviet doctrine. The combined effects of the SA-6 and the ZSU-23-4 proved insurmountable in the early phases of the battle. Only when the Israelis destroyed the Syrian air defense control center was the initiative gained. The final result of the air battle had proven the effectiveness of a new mobile threat by downing over 100 Israeli aircraft.[6]

The new mobile systems provided a maneuverable air defense system to the ground forces. While these systems

could not defend themselves against ground attack, the ability to maneuver with the ground forces reduced the problem. Developments in Soviet air defense continued to expound on the use of a mobile defense. The development of the SA-9/13 infrared air defense systems, and follow on systems such as the SA-8, SA-10, and SA-12 radar controlled systems continues to stress mobility.

Soviet air defense was reactive in the initial years. System development usually followed a deployed air threat in the battlefield. This characteristic has changed significantly over the years and development is continuing to improve as the number of follow on systems increase. This is another example which supports the premis that the Soviets have no desire to finish second to anyone.[7]

CONCEPTS IN AIR DEFENSE

The Soviet Union recognizes that air defense is an essential component of their combined arms force. As such, they have given the branch commander of air defense equal rank with the tank, motorized rifle, and artillery branches. The Soviets also know that NATO tactical air power is very effective and more flexible than their own. As attacking armies drive into West Germany, troops are forced into choke points where airstrikes could delay the forces, causing devastating losses to troops and equipment.[8]

The Soviet approach to air defense is normally described as the "three M" approach - mass, mix, and mobility. The first is a reflection of a standard principle of Soviet military art. This principle simply is that mass has a special impact, both psychological and physical, on the enemy. All things being equal, quantity will prevail.[9] Mass has never been a Soviet weakness. Antiaircraft artillery and surface-to-air missile systems provide coverage at all levels of command on a scale greater than any army in the world.[10]

The second principle of Soviet doctrine is mix. Here the effort of mass is reinforced by insuring coverage of every vital target by several types of missile and gun systems. This redundancy protects against possible technical failure, successful action against one type of surface threat, or possible enemy electronic countermeasures.[11] This overlapping of systems is shown in figure 3-1. Note that this figure only shows coverage by four ZSU-23-4s, two SA-8s, and one SA-6 system. Each Soviet Motorized Rifle and Tank division has approximately 16 ZSU-23-4s, 20 SA-6/11s and 20 SA-8s in the attached SAM regiment.[12]

Mobility is the final principle and is emphasized in weapons systems design. This has been proven during the past 20 years of antiaircraft system development. This design blends perfectly with ground force doctrine which envisions advances by tank forces up to 100 miles per day. This requires that air defense assets be capable of moving forward

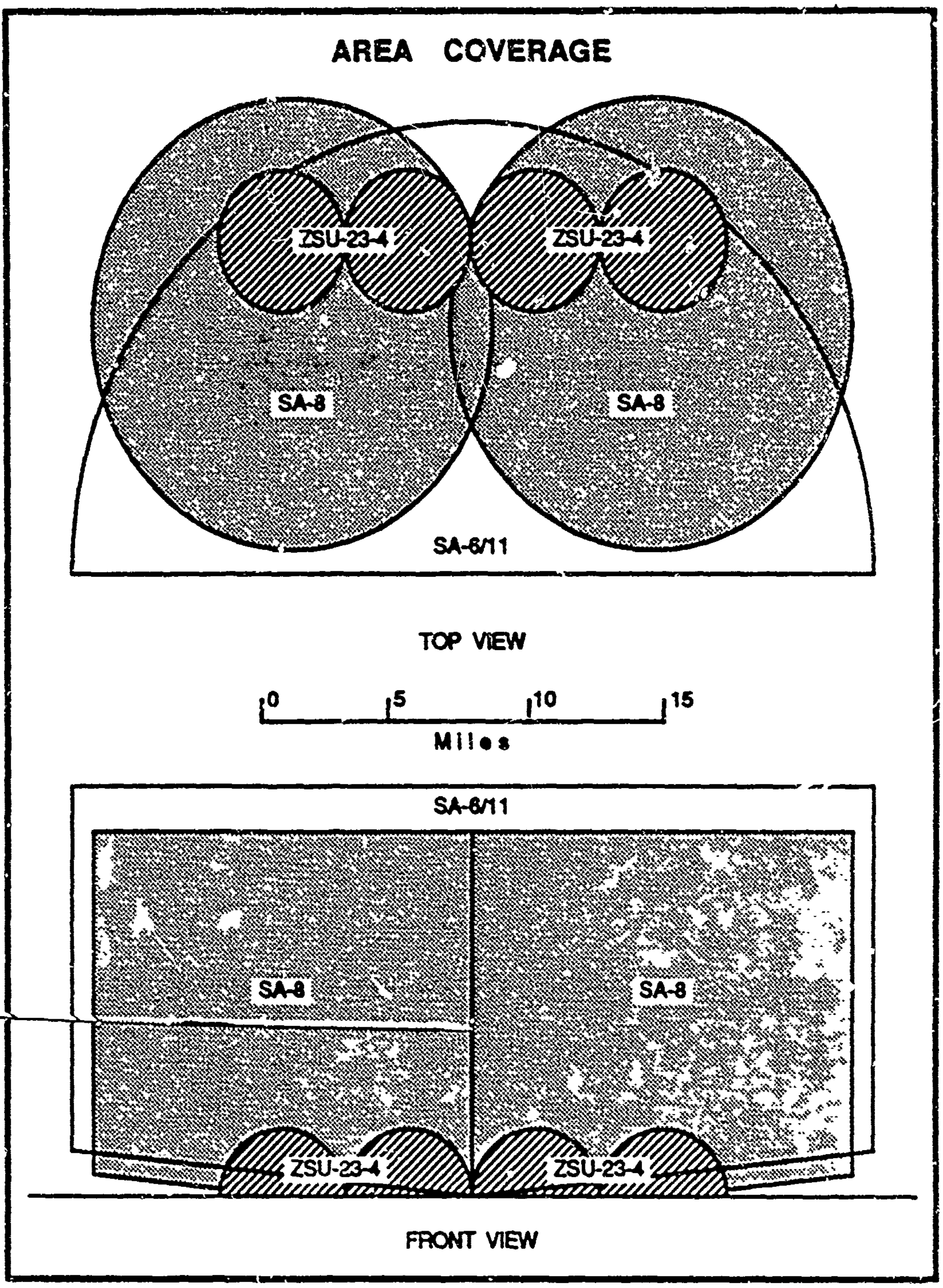
AREA COVERAGE
ZSU-23-4
ZSU-23-4
SA-8
SA-8
SA-6/11
TOP VIEW
0
5
10
15
Miles
SA-6/11
SA-8
SA-8
ZSU-23-4
ZSU-23-4
FRONT VIEW

FIGURE 3-1

rapidly to provide an air defense umbrella. The design of this mobile air defense umbrella provides protection to all ground forces from air attack. Simply, it is air superiority in reverse. A superiority of ground based units over tactical air power to such an extent that the aviation threat is eliminated or degraded to a satisfactory level.[13]

The importance of a mobile air defense umbrella to Soviet doctrine cannot be overemphasized. The Soviets feel the only way to win a decisive victory on the central front in Europe is to penetrate quickly into NATO's rear. This is necessary to allow the Warsaw Pact forces to destroy NATO's nuclear delivery capability and disrupt C^3 sites. Also, these forces must reach the western coast of France before the arrival of follow on forces from the United States and Canada.[14]

INTEGRATION OF AIR DEFENSE

When deploying an air defense weapon system, the Soviets apply a principle known as defense-in-depth. This allows the air defense systems to maneuver on the battlefield with the attached forces. Therefore, integration is accomplished at every tactical command level of the Soviet army, from the front surface-to-air missile brigade to the platoon's SA-7 launcher. This forms the Soviet's total air defense system.[15]

This air defense system includes area defense and point defense weapons. The front and army level SA-4 and newer SA-10 and SA-12 units provide area coverage. These systems protect all units on the front from aircraft flying at altitudes less than 13,000'. Point defense uses the SA-9/13 infrared systems and the radar controlled ZSU-23-4 antiaircraft gun for the protection of specific units. Therefore, these units must be positioned near the forces they defend due to their short lethal ranges. The SA-6/11 and SA-8 surface-to-air missile systems are used to bridge the gap between area coverage weapons and the point defense weapons. All weapon systems, whether used for point defense, area defense, or gap filling, tie into a comprehensive early warning and target acquisition network.[16]

The Soviet goal is to unify air defense assets under a single concept. If they do not have the advantage in the air, then the first priority is to launch an antiair operation. This provides their aviation assets freedom of movement while causing maximum destruction of enemy aircraft. To accomplish air superiority the Soviets will allow their aircraft to pass by using coordinated times and altitudes and destroy all others. Once obtaining the initiative in the air, the focus of air defense units would shift to a defensive action designed to protect their troops, installations and high priority assets.[17]

COMMAND AND CONTROL OF SOVIET AIR DEFENSE UNITS

Air defense officers are assigned at all headquarters down to regimental level. Although the air defense commander is subordinate to the ground commander which he is supporting, he is responsible for the coordination of all air defense efforts within the unit's area of operation. This includes th deployment of antiaircraft artillery, surface-to-air missile systems and associated radar. Also, he must establish coordination procedures with adjoining units, and determine the priority of areas to be defended. Control of air defense assets is highly centralized, especially when troops are in a static position such as an assembly area before an attack.[18]

Air defense communications must provide a timely warning of an air attack and control the distribution of antiaircraft fires. Types of communications used include colored rockets, flags, and radios. Redundancy is designed to insure receipt and duplicate commands are routinely issued. Information concerning an air threat is normally received by the battery commander via radio on the air defense net. This net is established for use by battery commander to the regimental air defense officer. Air threat data from the regimental level is relayed to the battery commander to warn of inbound aircraft. Warning of aircraft detected by an observation post is accomplished by firing one or two colored rockets in the direction of the inbound

aircraft. The duplication of this signal is a short code word transmitted by the company commander. The code word most frequently used is "vozdukh" (air) followed by three digits (123) which change on a routine basis.[19]

SOVIET AIR DEFENSE EMPLOYMENT

The "defense in depth" concept of air defense in a typical Soviet division begins with the air defense platoon assigned to the front companies. There are three men assigned to each platoon and nine platoons per battalion. Each man is equipped with an infrared heat seeking SA-7 missile. Higher priority divisions are equipped with additional protection in the form of a mobile SA-14 system. These air defense platoons will be the first units to engage an inbound aircraft.[20]

Air defense batteries provide the second layer of defense. These batteries support the regiments which they are assigned. They are equipped with a platoon of four ZSU-23-4 antiaircraft guns and a platoon of four SA-9/13 heat seeking surface-to-air missile systems.[21]

Although the ZSU-23-4 (NATO code name Shilka) is based on technology from the mid 50s, it is very lethal to aircraft within its range. It has a fire rate of 800-1000 rounds/minute/barrel with its four water cooled 23 millimeter guns. The maximum effective range is about 2500 meters, and the minimum engagement altitude is 200 feet. For aircraft

performing a close air support mission, the Shilka poses a serious threat when operating in the optical mode. In this mode, there are no electronic emissions and therefore no warning to the pilot when he is being engaged.[22]

Normally, the ZSU-23-4 systems are employed in pairs and kept within several hundred meters of one another. Additionally, they are usually within 400 meters of the regiments lead attack elements, provide quick response to threats, and have high rates of fire and excellent mobility.[22]

At the division level, the organic air defense system has either the SA-6/11 and SA-8 radar controlled surface-to-air missile systems. This air defense regiment is designed as a gap filler SAM system. It is expected to be the main threat to inbound fighters, especially aircraft on interdiction missions. Regiments equipped with the SA-6 (Gainful), have five batteries consisting of four transporter erector launchers (TEL), and a STRAIGHT FLUSH radar. The minimum equipment required to operate the SA-6 weapons system consists of two vehicles: a missile launcher and a radar vehicle. Both vehicles have tracks rather than wheels and are extremely mobile. The SA-11 system which replaces the SA-6 has a slight improvement in range and minimum altitude over the SA-6. However, its best feature is that each missile carrying vehicle has its own on board radar that can acquire, track and illuminate a target. This allows each SA-11

transporter erector launcher and radar (TELAR) to operate autonomously in the battlefield rather than being tied to a single radar as is the SA-6. This improvement gives the SA-11 the capability to track four targets per battery, rather than a single target which could be tracked and fired upon by the SA-6.[24]

The SA-6/11 missile systems are capable of slant ranges out to about 18 miles at lower altitudes and a minimum engagement altitude of 100 feet. Design features include high resistance to electronic countermeasures and added electronic counter-countermeasures which include an optical tracking device.[25]

The SA-8 (Gecko) surface-to-air missile system is the worlds first truly "mobile" radar system. It is self-contained, amphibious, and has the LAND ROLL radar for target acquisition and fire control. The six-wheeled vehicle has a boat like appearance, and carries either four or six missiles. The amphibious characteristic of the SA-8 provides some mobility and tactical advantages over the the SA-6/11 tracked systems. However, the SA-6/11 systems provide greater depth of coverage, giving them an advantage in operational maneuver group type operations. The SA-8's ability to travel at higher speeds on prepared surfaces, combined with its amphibious capability, makes it more suitable for exploitation and pursuit operations.[26]

The SA-8 is deployed with five batteries per division and each battery contains four TELARs. The SA-8's ability to operate independent of other radars insures coverage throughout the operation area. However, for enhanced survivability, the SA-8 will probably be deployed in a two to four vehicle formation to improve detection and early warning capability. This will reduce the area of coverage somewhat, but still provide the flexibility needed on the battlefield.[27]

The SA-8 is a short range maneuverable missile designed to engage high performance fighters at low altitude. The Gecko system has the ability to engage two separate targets and guide two missiles to each engaged target. The maximum range is estimated at 7.5 miles and the minimum engagement altitude is thought to be near 130'.[28]

Figure 3-2 shows the capabilities of current Soviet radar controlled air defense systems.

SOVIET AIR DEFENSE WEAKNESSES

One of the potential weaknesses of the Soviet air defense system is the high level of centralization which is used. These command and control networks could fail under the intense pressures of battle. Coordination between ground air defense units, air-to-air defense fighters, and frontal aviation offensive air units is essential to prevent the amicide of friendly air assets. Also, Soviet air defense

	SA-6	SA-8	SA-10	SA-12	ZSU 23-4	ZSU 30-2
MAX RANGE:	18	8	55	60+	2500M	3800M
MIN ALTITUDE:	300'	100'	100'	300'	200'	200'
WARHEAD:	176#	39#	UNK	UNK	23mm	30mm
DATE OF OPERATION:	1970	1974	1978	1985	1972	1983

FIGURE 3-2

units might fail to maintain pace with ground units while trying to "leap frog" defense assets. "Leap frogging" allows the air defense commander to maintain two batteries in preparation for firing, while the other three batteries move forward with the organic troops. The air defense "umbrella" may lag behind the fighting units and expose them to ground attacks by aircraft and helicopters. The only alternative to the ground commander is to slow the pace of advance which would considerably reduce the chance for success.[29]

Another problem for the air defense systems is their location to the forward edge of the battle area. Here they are very vulnerable to ground fire, especially artillery and rocket fire. These vehicles are not heavily armored and the

sensitivity of the radar antenna to shell fragments could remove it from service. This makes all air defense systems especially vulnerable. During river crossing operations or in choke points, these vehicles become grouped together and defense of the ground forces becomes critical. Resupply, equipment, and ammunition for the fast moving air defense forces may also be a problem during combat as well as the lack of amphibious capability on all systems except the SA-8.[30]

Each Soviet air defense system also has individual weaknesses. One article written on the ZSU-23-4 mentions several problems. These include variation in ammunition character, rapid gun barrel deterioration, and electrical problems associated with the radar controlled firing of the guns which include the possibility of a runaway or uncontrolled firing. Another drawback to the ZSU-23-4 is its limited supply of ammunition.[31]

The basic load of 2,000 rounds can be fired in only 25 seconds. Therefore, when unable to follow economy of fire rules (bursts of fire of about 200 rounds per target), the ZSU-23-4 will require frequent resupply, therefore increasing its vulnerability.[32] A ZSU-23-4 under artillery fire or an attack by aircraft, must retract its radar antenna to prevent damage from the fragmentation. Additionally, the crew must close up all hatches, making it impossible to detect aircraft either visually or with radar. Finally, attack helicopters

armed with the TOW (Tube launched, Optically tracked, Wire command) antitank missiles can destroy the ZSU-23-4 by attacking from a maximum range of 3,750 meters which is outside the ZSU-23-4's range.[33]

The SA-6 missile system destroyed large numbers of Israeli aircraft during the first two hours of the 1973 war. However, this was largely due to technological surprise. Once this surprise disappeared, the effectiveness of the SA-6 declined. By the end of the war, the overall accuracy rate was only about 1.8 percent. The Egyptians fired over 55 missiles for each kill scored. Obviously, it is not a wonder weapon. The initial threat of the SA-6 did, however, prevent the Israelis from striking targets which otherwise might have been attacked.[34]

The Soviets use of vacuum tubes in their systems increases the fragility and bulk of the items. However, miniturization has never been a concern of the Soviet Army or the Soviet society as a whole. While the Soviets are far behind Western countries in transistor and computer technology, their vacuum tube technology places them ahead of Western technology by 10-15 years. The disadvantage of tube technology was evidenced during the 1973 Arab-Israeli War when temperatures inside radar vans approached 160 degrees fahrenheit.[35]

Initial effectiveness expected of any system will be considerably higher at the start of a conflict. This

effectiveness will decline as a countermeasure is developed for the threat system. This "wizard war" will continue on both sides, with each searching for a countermeasure and a counter to the countermeasure.

TRENDS IN SOVIET AIR DEFENSE

Overall, the Soviets are numerically superior in air defense weapons compared to any military force in the world. In addition, they currently have the air defense organizations and equipment to react quickly to a threat. Recently, the Soviets reorganized the PVO STRANY air defense structure to improve control over its 10,000 surface-to-air missiles and 2,500 fighter interceptors. The threat had evolved from a high flying strategic bombing force to a very low altitude tactical force. In the new reorganization, the air forces receive control of several air interceptor units. This allows the ground commanders to take an increased responsibility for air defense and gives air commanders more flexibility to conduct either offensive or defensive operations. Another apparent reason for the reorganization is to decrease command and control problems. This allows land force commanders to destroy aircraft and cruise missiles at a lower altitude where the surface-to-air defense assets are more effective than interceptors.[36]

Another trend seen recently in Soviet air defense systems is the increase in size of the engagement envelope

and lethality of the weapon. Also, the modified SA-8 can carry six missiles in canisters rather than four as it was originally designed. New weapon systems also have redundant missile guidance systems providing an enhanced ability to conduct a successful engagement.[37]

SA-4 units, which normally protect headquarters' facilities and high value assets, are being replaced by the SA-10 and SA-12 systems. These new systems use a phased array radar for multiple target capability and also reportedly have the capability to intercept cruise missiles. The SA-10 has a maximum range of about 57 miles, while that of the SA-12 is in excess of 60 miles. The minimum altitude of 300 feet for the SA-12 is higher than the 100 feet assumed for the SA-10.[38] This higher engagement altitude is due to the primary strategic role designated for the SA-12.

Another new system placed in service in 1983, is the ZSU-30-2. This system is a follow on to the ZSU-23-4 and has overcome many of its predecessor's problems. It is armed with two 30 millimeter guns which are thought to have a range out to 3,800 meters. Also, the vehicle's hull is believed to be based on that of the T-72 tank. The new system is expected to have an improved target tracking capability which includes low light TV, electro-optical, infrared, acoustic, and radar systems.[39]

Improvements in recent years in microcomputer and transistor technology approach state-of-the-art. It is

reported that the latest Soviet radar and surface-to-air missile systems now use transistors and printed integrated circuits.[40]

SUMMARY

In conclusion, the Soviet ground based tactical air defense system presents a formidable threat to any type of aircraft. The quality of Soviet air defense systems appears to be near that of the Western nations and they are unmatched in quantity. They have the ability to continue improving air defense assets, and presently display the capability for a quick and effective response to any foreign threat.[41]

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CHAPTER THREE

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CHAPTER 4

ATTRITION OF THE FORCES

During World War II, attrition rates approached 40 percent on some high priority missions, and the Allied air forces lost approximately 40,000 aircraft.[1] NATO air forces currently have limited numbers of aircraft and a restricted industrial base to replace destroyed aircraft.[2] The total front line aircraft in NATO in 1987 was approximately 2,990 compared to 7,240 for the Warsaw Pact nations.[3] This number advantage is due to the increased emphasis on quality over quantity by the NATO allies.[4] The Allies cannot accept a high or even moderate level of attrition. Low attrition rates can assure a sustained air capability over an extended period.

Attrition reduces the combat force of air power delivered against the enemy. Some combat studies have shown that units become ineffective when half of the force has been attrited. Units become ineffective because the remaining forces do not have the ability to gain or maintain air superiority at levels below 50 percent.[5] This is due to a decrease in aircraft and the inability to mass forces against the threat. Actually, as forces are reduced, attrition rates

will increase rather than remain constant.

Figure 4-1 shows the number of aircraft remaining over a 30 day period for four different attrition rates.

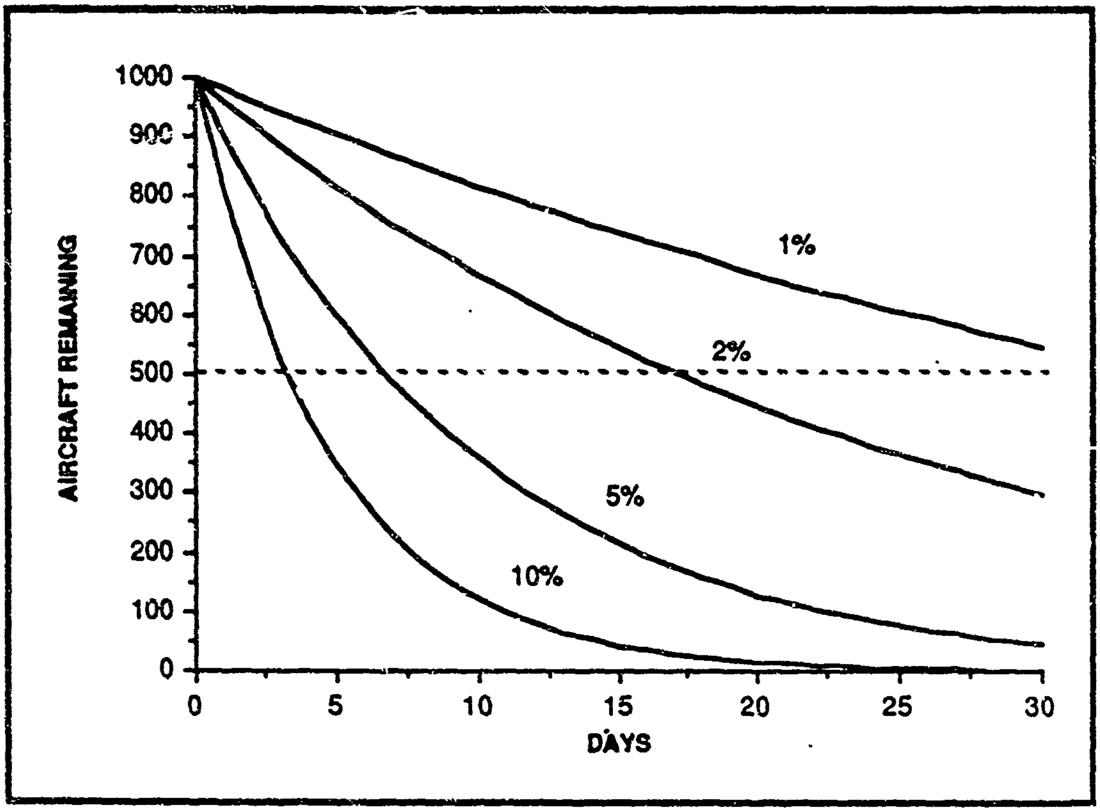

FIGURE 4-1

An attrition rate of one percent will result in a loss of 455 aircraft over a 30 day period. At this rate the

air power assets remain above 50 percent and maintain a viable combat force throughout the period. When attrition rates increase to two percent, combat effectiveness is maintained for only 18 days. As attrition rates increase to five percent, the combat effectiveness time drops to only seven days. At 10 percent attrition, the Allied air forces could only launch seven mass attacks over a 3.5 day period before becoming combat ineffective.[6] The number of aircraft remaining after each attack will directly impact the ability to produce sorties and attack the enemy's capability to wage war.

Figure 4-2 shows the impact on sortie production for a force of 1,000 aircraft at different attrition rates. Here the sorties flown include only those sorties flown before the force is reduced to a 50 percent level. Sorties for each attrition level represent two sorties per day.

At the 1 percent attrition rate, total sorties generated by the NATO air forces would be 45,235. Raising the attrition rate by only one percent at these low levels, reduces sorties produced by almost 44 percent. As before, increased attrition rates drastically reduce the available aircraft and sortie generation capability. Clearly, Allied air forces must limit the attrition of their air power to ensure a victory in the air and on the ground.[7]

There are basically six methods to reduce attrition. The first method is to avoid the threat by flying a ground

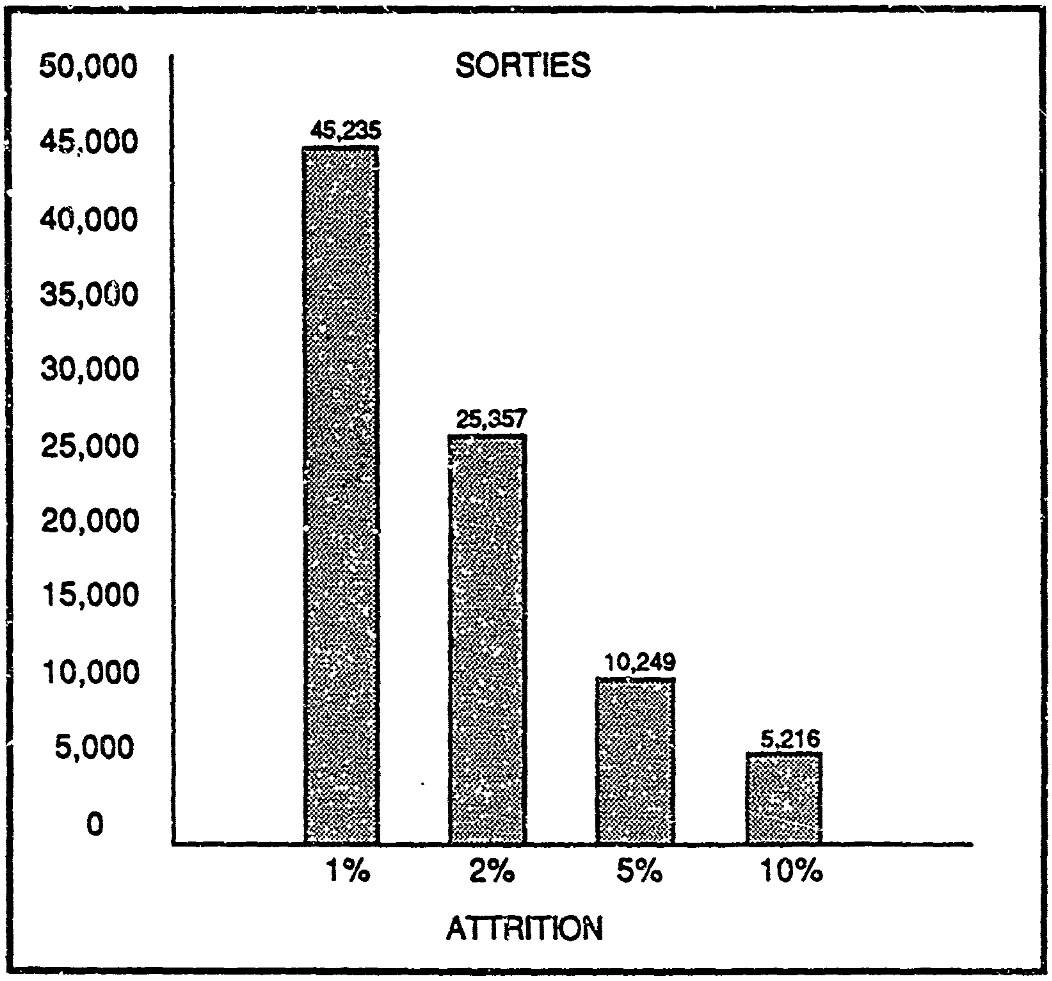

FIGURE 4-2

track outside of the system's range. This method is somewhat effective, however, almost every square mile of Europe is covered by radar, and fighters are always within the engagement envelope of a surface to air missile system.[8] The second method is to launch mass attacks. This will reduce the probability of intercept of an aircraft by saturating the enemy radar system and reducing engagement time. The other

methods which reduce attrition are acquisition and tracking countermeasures, terminal countermeasures, decoys, and lethal suppression.[9] The following analysis focuses only on the lethal defense suppression aspect of reducing aircraft attrition. The analysis will look at the cost of aircraft and the effects of sortie production on a strike force. Additionally, it will analyze the cost of weapons used to suppress the threat radars and determine the additional reduction of attrition required to pay for the weapons.

AIRCRAFT COST ANALYSIS

This analysis will determine the break-even point where Wild Weasel defense suppression assets become cost effective in reducing attrition. To accomplish this an aircraft cost factor will be determined to show how the strike aircraft force will be reduced when purchasing the defense suppression assets. Stephen Holliday determined in a study for the U.S. Air Force Systems Command that F-4G Wild Weasel aircraft cost 1.4 times that of a strike fighter. Using this factor, constant 1977 dollars, and 10 year life cycle costs, 40 Wild Weasel aircraft will cost the equivalent of 57 strike aircraft.[10] This cost for Wild Weasel aircraft is then removed from the initial base of 1,000 strike aircraft resulting in a base of 943 strike aircraft. This 5.7 percent decrease in the strike aircraft force is the cost for Wild Weasel defense suppression assets. Cost

effectiveness for the Wild Weasel will be determined by sortie production during a given period. The break-even point is achieved when the attrition rate of the 943 aircraft is reduced to a point where they can produce as many sorties as the 1,000 aircraft force without defense suppression assets.[11]

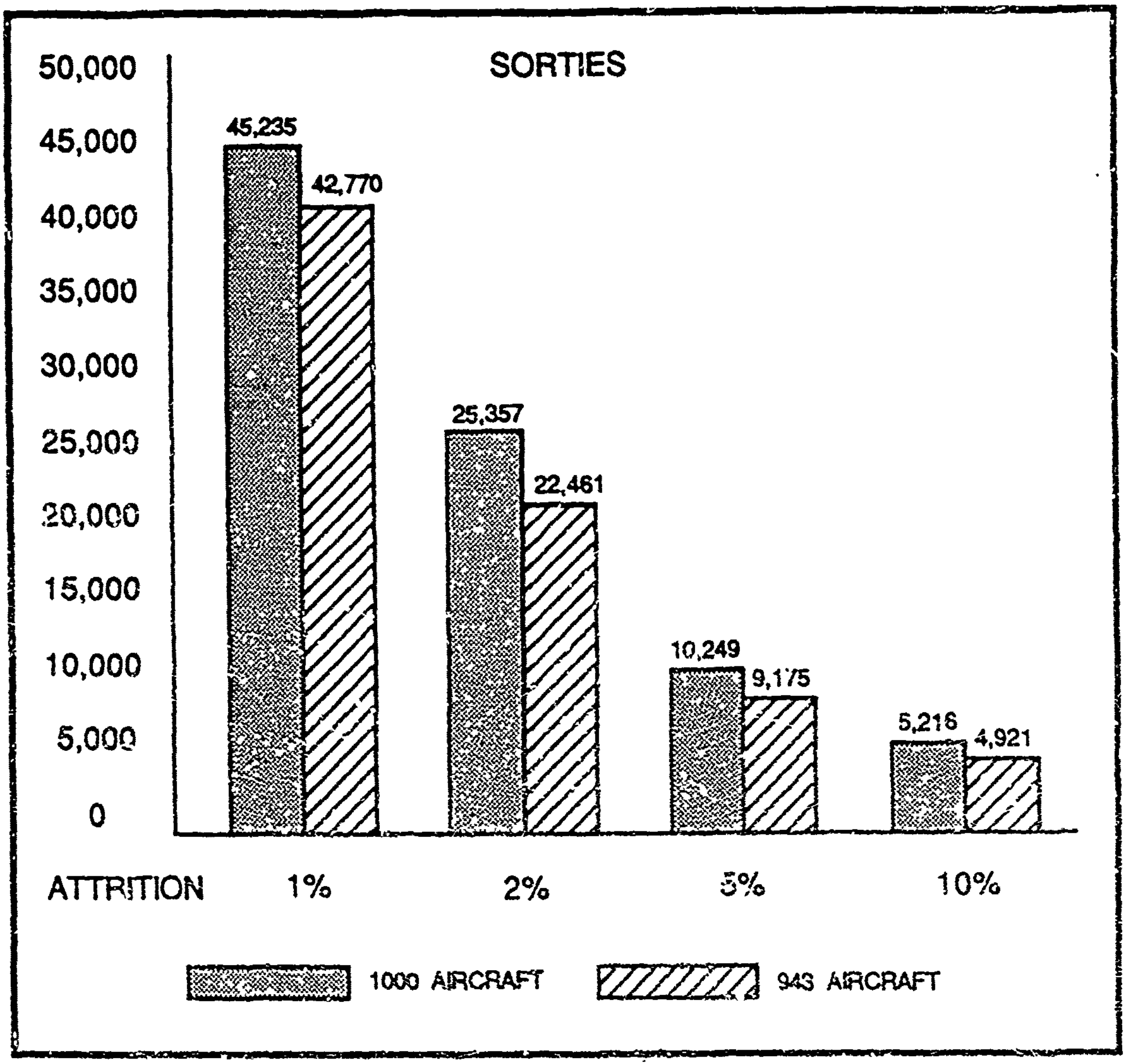

FIGURE 4-3

Figure 4-3 compares sortie production of a 943 aircraft force and a 1,000 aircraft force at several attrition rates using either 30 days or combat ineffectiveness which ever occurs first. In the early phases of a conflict or in a short one or two day conflict, the 1,000 aircraft force can produce more sorties than a force with Wild Weasel defense suppression assets. However, this analysis will look at the ability of a force to produce sorties over a thirty day period for the one percent attrition level or until half of the force is attrited for higher attrition levels.

Wild Weasels become cost effective, or reach the break-even point, when the attrition rate is reduced 13.2 percent. As illustrated in Figure 4-4, using an attrition rate of 10 percent, the Wild Weasel becomes cost effective when attrition is reduced by 13.2 percent to 8.68 percent. This is shown by comparing the sorties produced by 1,000 strike aircraft at a 10 percent attrition rate and the sorties produced by 943 aircraft at an 8.68 percent attrition rate. By reducing attrition rates 13.2 percent the 943 aircraft can produce 5,610 sorties. This is an increase of almost 400 sorties over the 10 percent rate for 1,000 strike aircraft. This increase is due to one additional mass launch which is achieved prior to reaching the 50 percent combat ineffective level.

The 13 percent break even point for cost effectiveness also holds true at the 5 percent attrition rate. Here, the Allied air forces can produce 10,249 sorties over a seven day period with a 1,000 aircraft strike force. Using a 13 percent reduction to 4.35 percent, the 943 aircraft with Wild Weasel assets can produce 10,558 sorties.

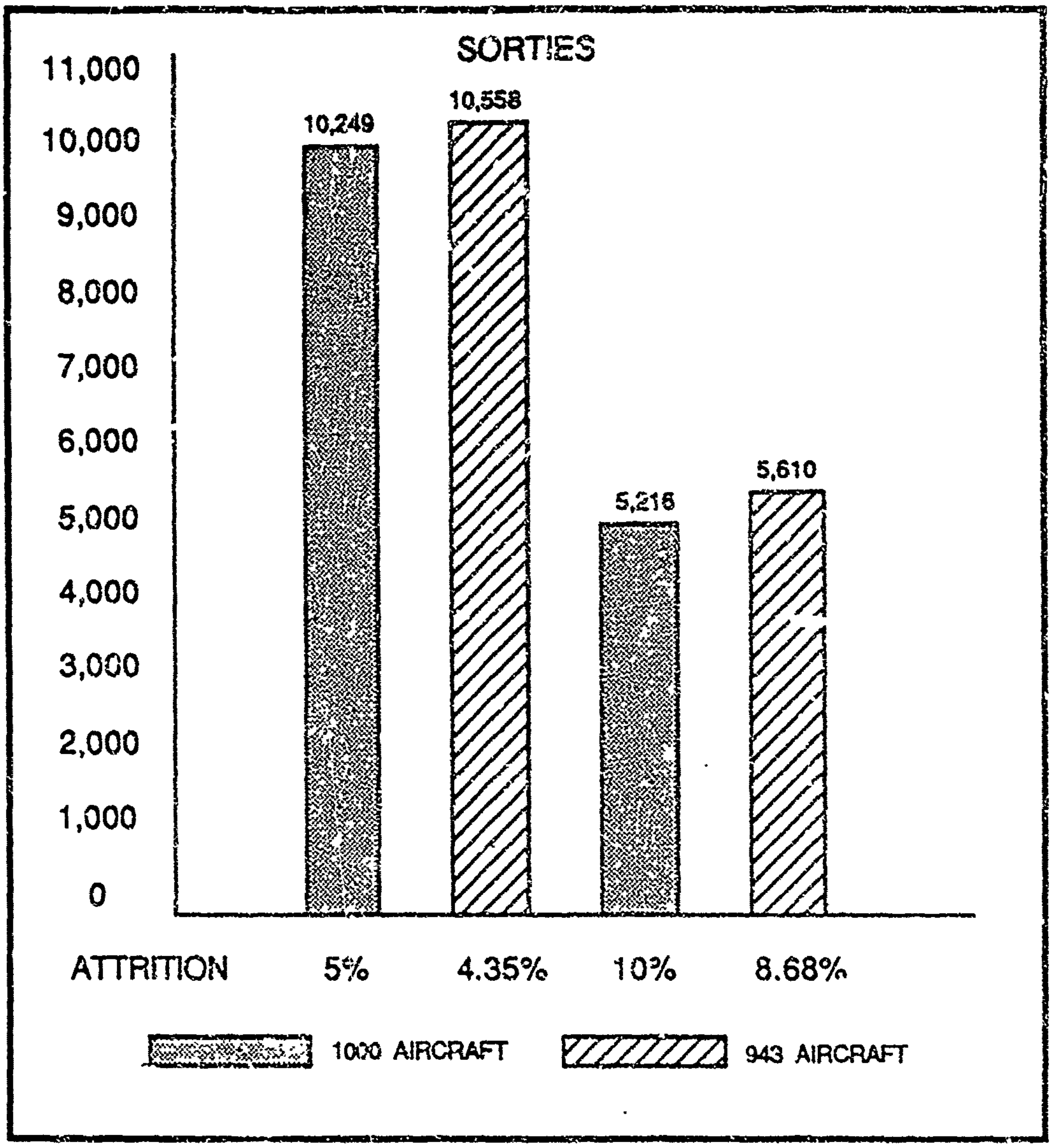

FIGURE 4-4

MISSILE COST ANALYSIS

The cost of weapons and the number of kills achieved per dollar are other aspects of cost effectiveness. Using the 8.68 percent base attrition rate for 943 aircraft you can only fly for four days before the force becomes combat ineffective. Therefore, the 40 Wild Weasel aircraft fly two sorties per day for a total of 320 sorties during the four day period. Wild Weasel aircraft carrying one Shrike and one HARM on each sortie could launch a total of 640 missiles. The maximum cost of a shrike, when in production, was $50,000.[12] The HARM program is a joint Air Force-Navy venture with each missile initially planned to have a cost of $225,000.[13] Both weapons cost estimates use constant fiscal 1983 dollars. The cost for 640 missiles fired during four days of suppression would be $88.0 million. The current replacement cost for a fighter is $15 million dollars.[14] Therefore, the Wild Weasel must reduce attrition only two tenths of one percent to save six aircraft during the four day period and pay for the missiles. The cost of missiles, while expensive, is shown to be a very cost effective measure when compared to fighter aircraft replacement.

An additional benefit of lethal defense suppression is the physical destruction of the threat radar itself. To determine enemy losses the analysis uses an operational probability of kill (Pk) for a typical ARM is .30 Pk and estimates the Pk for the Harm to be .50 Pk.[15] Therefore,

using an average .40 Pk, Wild Weasels could destroy 256 mobile SAM systems in a four day period. This equates to almost four full Soviet SAM Regiments or all of the ZSU-23-4's across a 100 kilometer front.[16]

HISTORICAL EVIDENCE

There is no doubt that the application of electronic countermeasures during Vietnam led to a decrease of attrition rates and aircraft losses. In the early stages of the conflict the loss rate was over 14 percent. This was reduced to 1.4 percent in the closing stages of the war with the use of self-protection systems, stand-off jamming, and Wild Weasel aircraft. The effective use of only three elements of electronic combat contributed to a 30 percent decrease in attrition.[17]

In the 1973 Arab-Israeli war, the Israeli air forces lost over 80 aircraft during the first few days to the SA-6 and ZSU-23-4. Following a resupply of electronic countermeasures gear and a change in tactics, the Israeli air forces lost only 35 aircraft in the following 11 day period. This was a reduction in losses from almost 27 aircraft per day in the first few days to only three aircraft per day at last. The effectiveness of the SA-6 was also reduced to a point where over 50 missiles were fired for each aircraft kill.[18]

The role of electronic combat during the Bekaa Valley debacle and the Libya raid cannot be quantified due to

the short duration of the conflicts. However, it is believed that the emphasis on electronic combat assets during both attacks kept attrition at a minimum. The loss of only one aircraft during each of the attacks shows a low attrition rate for the single strike missions.[19]

SUMMARY

These examples have shown that Wild Weasel assets become cost effective by reducing attrition of the fighter force by only a small percentage. Additionally, when attrition is reduced an additional 0.68 percent from the 8.68 percent break even point to 8.0 percent, sortie production will increase by 150 sorties in a four day period. While this increase in sorties is important, the most important aspect is that an additional 26 aircraft will be saved during that period. The result is a cost savings of $390 million in aircraft alone, to say nothing of lives saved in addition to an immeasurable increase in the projection of tactical air power.

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CHAPTER 5

CONCLUSIONS

A fighter pilot can deliver his ordnance and expend his ammunition in less than 20 seconds. The task of the Wild Weasel defense suppression assets is to ensure that the fighter pilot survives long enough to employ his fighter and its weapons, return home, and repeat the task.[1]

The United States Air Force performed a study to determine the survival probability of an aircraft during a conflict in central Germany The survival probability was determined to be only 50 percent per mission. With an initial force of 1,000 aircraft, only one aircraft would be remaining after 10 missions. Decreasing the attrition to 20 percent only gives the pilot one chance in three of surviving the first five days of the war. When attrition is reduced to 1 percent, the fighter pilot has a 82 percent chance of living through the first five days of a conflict.[2]

In 1987, NATO forces had 2,990 front line aircraft compared to the 7,240 aircraft of the Warsaw Pact Nations.[3] Outnumbered by a 2.4 to 1 ratio in aircraft alone, there is no doubt that military planners must keep attrition at a minimum to assure a sustained air capability over an extended

period. Additionally, the Allied forces have a limited industrial base and corresponding ability to replace fighter aircraft in a timely manner.[4] The question then is how to provide a lower attrition rate and ensure a viable air threat to oppose the enemy.

This paper looks at three aspects which show the viability of defense suppression assets, especially those with a lethal destruction capability. First, is the historical aspect of the Wild Weasel. This aerial electronic combat began in World War II, and throughout recent history has proven to lower attrition rates of strike aircraft, either through destruction or disruption. Secondly, the Soviet threat which has evolved in recent years is second to none in quantity and quality improvements are approaching that of the western nations. Finally, a look at attrition of friendly forces, and a cost analysis examination determines that Wild Weasel assets become cost effective with only a small reduction in attrition.

HISTORY

The basis of aerial electronic combat began in World War II. Effective use of these assets showed that the effectiveness of combat forces varied as the square of their size. Assuming a force acted coherently, then 10 aircraft acting together would be 10 times more effective when compared to 10 aircraft acting independently.

In addition to using coordinated attacks, the planners began to use B-17 aircraft to escort the strike force to the target.[5] Also, P-47's equipped with radar homing devices, allowed the pilot to attack German radar sites and was the first use of the Wild Weasel concept.[6] During the Korean conflict, the Air Force employed TB-25J "Ferrets."[7] However, it was not until July 1965, when the first F-4 fighter was downed by an SA-2, that the Pentagon allowed the Air Force and Navy to resurrect the idea of radar bombers similar to the P-47's during World War II.

The answer was the Wild Weasel system which combined a pilot and an electronic warfare officer (EWO) in a tactical fighter aircraft. Their job was descriptively called "Weasel" because they were to ferret out and suppress or destroy the enemy's surface-to-air missile sites and radar controlled antiaircraft guns.[8] One of the reasons for initiating the Wild Weasel concept was the sheer numbers of defensive systems deployed in North Vietnam. Three years after the first aircraft was downed by a SA-2, there were several hundred SAM sites and over 8,000 radar controlled guns in North Vietnam.[9]

In 1972, prior to Linebacker I operations, 11 B-52's were downed in two days. Modified tactics forced the North Vietnamese radar operators to shut down their radar to protect themselves from antiradiation missiles and bombing attacks by the Wild Weasels. The result was a dramatic

decline in losses.[10]

In 1967, one aircraft was downed for every 55 SA-2 missiles fired. Prior to 1972, the rate went to almost 100 missiles for each aircraft lost, and during Linebacker I, the rate was more than 150 missiles.[11] In addition, the attrition rate dropped from 14 percent in the initial phases of the conflict to 1.4 percent in the end. A reduction of 90 percent with the use of electronic combat assets.[12]

The Arab-Israeli wars also proved the value of electronic combat. Initially during the 1973 Yom Kippur War, the Israeli air forces were denied air superiority over the battlefield. This was not due to enemy air power, but to the ground mobile air defense systems provided to the Arabs by the Soviet Union. The effectiveness of the mobile SA-6 was exceeded only by that of the ZSU-23-4 antiaircraft gun system.[13] It was not until Israel lost over 80 aircraft in the first few days that they employed electronic combat assets. In the end, electronic assets and smart tactics reduced the effectiveness of the SA-6 to a point where it required over 50 missiles to achieve a single kill.[14]

Planners have learned the importance of electronic combat. This was proven during the 1982 Bekaa Valley debacle and again in the 1986 Libya raid, where employment of the proper electronic combat assets kept attrition rates at minimum levels.[15]

THE SOVIET THREAT

The threat is an important reason for employing lethal defense suppression assets. The Soviets realize the importance NATO places on tactical air power in the interdiction role. Additionally, they admit the NATO air threat cannot be eliminated. However, proper employment of air defense systems can reduce the damage imposed by tactical airpower to a level that does not slow the momentum of attack.[16] World War II data shows that any antiaircraft fire, no mater how accurate, was sufficient to reduce bombing accuracy by at least 50 percent.[17]

Soviet doctrine is based on reducing tactical air effectiveness by using three principals: mass, mix, and mobility.[18] Mass has never been a Soviet weakness and current estimates show over 1,800 SAM and 1,500 acquisition radar sites in central Europe alone.[19] The principle of mix insures coverage of every vital target on the battlefield by several types of missile and gun systems. This redundancy protects against possible technical failure, successful action against one type of threat, or enemy electronic countermeasures.[20] Mobility is the final principle and is emphasized in the design of weapon system. This design blends perfectly with the ground force doctrine which envisions advances of tank forces up to 100 miles per day.

The importance of a mobile air defense system cannot be over emphasized. The Soviets feel the only way to win a

decisive victory on the central front in Europe is to penetrate quickly into NATO's rear. This quick thrust is necessary to allow Warsaw Pact forces to destroy NATO's nuclear delivery capability and disrupt command, control and communication sites.[21]

Overall, the Soviets are numerically superior in air defense weapons to any military force in the world. Additionally, another recent trend is the quality of new weapon systems. New weapons systems incorporate phased array radar[22] and have redundant guidance systems to provide an enhanced ability to conduct a successful engagement.[23]

The Soviet ground based tactical air defense system presents a formidable threat to any type of aircraft. The quality of these systems appears to be near that of western nations and they are unmatched in quantity. Finally, they have the ability to continue improvements in air defense assets, and currently display the capability for a quick and effective response to any foreign threat.[24]

ATTRITION AND COST EFFECTIVENESS

Attrition reduces the ability to deliver combat power against an enemy by air power. As units are attrited, they become ineffective, since the remaining forces do not have the ability to gain or maintain air superiority. This is especially true as forces are reduced below a 50 percent level.[25] The Warsaw Pact nations in central Europe have

a 2.4 to 1 advantage over the NATO Allies in front line fighters. Therefore, keeping attrition rates at minimum levels is paramount in order for the air forces to remain a viable force.

There are basically six methods which can be used to reduce attrition. First is to avoid the threat engagement area. This method is effective, however, almost every square mile of central Europe is currently within the engagement envelope of a radar controlled system.[26] The second method is to launch mass attacks. This will reduce the probability of intercept of each aircraft by saturating the enemy radar system and overcoming his capability to engage the airborne threat. The remaining methods used to reduce attrition are acquisition and tracking countermeasures, which include airborne jamming systems; terminal countermeasures which include ECM pods on the aircraft itself; decoys, including remotely piloted vehicles and drones; and lethal suppression, which includes Wild Weasel assets.[27]

Analysis shows that Wild Weasels become cost effective when reducing attrition by approximately 13 percent. When attrition is reduced 13 percent from a baseline rate of 10 percent to 8.68 percent, a strike force with defense suppression assets can produce approximately the same number of sorties before becoming non-effective. Additionally, the cost of antiradiation missiles are relatively low when compared to replacing a $15 million

dollar fighters. Analysis also shows that Wild Weasels would only have to reduce attrition by an additional two tenths of one percent to pay for the missiles used in a defense suppression role.

One aspect not studied is the effect antiradiation missiles have on attrition of enemy SAM systems. Using an average Pk of .40 for Shrikes and HARMs, Weasels could destroy 128 mobile SAM systems in a four day period. This equates to two full Soviet SAM regiments or all of the ZSU-23-4's across a 50 kilometer front.[28] Additionally, the depth of study did not allow the determination of either hard or soft kills, however, it can be seen that over a period of time the attrition of enemy SAM systems could be quite effective.

A study accomplished by Stephen Holliday in 1976, for the U.S. Air Force Systems Command,[29] recommended three methods to improve the cost effectiveness of the Wild Weasel in the lethal defense suppression role. First, was to improve the antiradiation missile capability. Production of the HARM in recent years, the air launched drone program and the Sidearm missile have accomplished this. Second, was to improve tactics. With the addition of a new tactical electronic combat range in Europe, all electronic combat crews have improved training capabilities.[30] The last method is to increase the number of weapons carried by the Wild Weasel. With delivery of the Sidearm missile and the Tacit

Rainbow air launched drone, the Wild Weasel will be capable of carrying up to 10 weapons rather than two as before. Holliday's study concluded that "the Wild Weasel only need one kill for each sortie for the hunter-killer concept to become <u>very</u> cost effective".[31]

SUMMARY

The main focus of this study has been to show the validity of the Wild Weasel concept when compared to the threat, historically, and to determine when the Wild Weasel assets become cost effective in reducing attrition of the fighter force. In conclusion, history has proven that the Wild Weasels can reduce attrition rates and that they are a viable asset. Also, there is a continued threat from the Soviet Union in both quantity and quality. And finally, the attrition and cost analysis determined that the Wild Weasel assets only have to reduce fighter attrition by 13.2% to become cost effective.

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APPENDICES

DEFINITIONS

Air Superiority: That degree of dominance in the air battle of one force over another which permits the conduct of operations by the former and its related land, sea, and air forces at a given time and place without prohibitive interference by the opposing force. (JCS Pub Number 1)

Air Supremacy: That degree of air superiority wherein the opposing air force is incapable of effective interference. (JCS Pub Number 1)

Antiradiation missile: A missile which homes passively on a radiation source. (JCS Pub Number 1)

Attrition: The reduction of the effectiveness of a force caused by loss of personnel and material. (JSC Pub Number 1)

Attrition Rate: A factor, normally expressed as percentage, reflecting the degree of losses of personnel or material due to various causes within a specified period of time. (JCS Pub Number 1)

Combined Force: A military force composed of elements of two or more Allied nations. (JCS Pub Number 1)

Command, Control and Communications Countermeasures (C^3CM): The integrated use of operations security (opsec), military deception, jamming, and physical destruction, supported by intelligence, to deny information to, influence, degrade, or destroy adversary C^3 capabilities and to protect friendly C^3 against such actions. (AFM 2-8)

Command, Control and Communications (C^3) Protection: That division of C^3 countermeasures comprising measures taken to maintain the effectiveness of friendly C^3 despite both adversary and friendly counter C^3 actions. (AFM 2-8)

Complementary Suppression: Suppression engagements conducted by aircraft in self-defense and the offensive attack against surface-to-air targets of opportunity by other weapon systems. (JCS Pub Number 1)

Counter Air: Aerospace operations which gain control of the aerospace environment. Counter air operations protect friendly forces, ensure our freedom to use the aerospace environment to perform our other missions and tasks, and deny the use of that environment ot an enemy. The ultimate goal of counter air is air supremacy. (AFM 1-1)

Counter Command, Control, and Communications (C^3): That division of C^3 countermeasures comprising measures taken to deny adversary commanders and other decision makers the ability to command and control their forces effectively. (AFM 2-8)

Deception: Those measures designed to mislead the enemy by manipulation, distortion, or falsification of evidence to induce him to react in a manner prejudicial to his interests. (JCS Pub Number 1).

Defense Suppression: Secondary objective of air attack on enemy territory, to reduce or eliminate antiaircraft defenses. (Janes Aerospace Dictionary).

Destructive Means: Military action employed to physically damage or destroy enemy surface-to-air systems or personnel. (TAC Pamphlet 50-24)

Disruptive Means: Military action employed to damage, degrade, deceive, delay, or neutralize enemy surface-to-air systems temporarily. There are two types of disruptive means: active and passive. Active includes jamming, chaff, flares, and tactics such as deception and avoidance/evasion flight profiles. Passive includes camouflage, infrared shielding, warning receivers, and material design features. (TAC Pamphlet 50-24)

Electromagnetic Spectrum: The frequencies (or wave lengths) present in a given electromagnetic radiation. A particular spectrum could include a single frequency or a wide range of frequencies. (JCS Pub Number 1)

Electronic Combat: Action taken in support of military operations against the enemies electromagnetic capabilities. Electronic combat includes Electronic Warfare (EW), as well as elements of Command, Control and Communications Countermeasures, and Suppression of Enemy Air Defenses (SEAD). (Air Force Manual 2-8)

Electronic Countermeasures (ECM): That division of electronic warfare involving actions taken to prevent or reduce an enemy's effective use of the electromagnetic spectrum. (AFM 2-8)

Electronic Counter-Countermeasures (ECCM): That division of electronic warfare involving actions taken to ensure friendly effective use of the electromagnetic spectrum despite the enemy's use of electronic warfare. (AFM 2-8)

Electronic Jamming: The deliberate radiation, reradiation, or reflection of electromagnetic energy for the purpose of disrupting, obliterating, or obscuring signals which the enemy is attempting to receive. (AFM 2-8, JCS Pub Number 1)

Electronic Order of Battle (EOB): Derived from electronic intelligence analysis. An EOB provides the number, system type, location, and various other aspects of a designated force's equipment status. (AFM 2-8)

Electronic Warfare: Military action involving the use of electromagnetic energy to determine, exploit, reduce, or prevent hostile use of the electromagnetic spectrum and action which retains friendly use of the electromagnetic spectrum. There are three divisions within electronic warfare: (a) electronic warfare support measures (ESM), electronic countermeasures (ECM), and electronic counter-countermeasures (ECCM). (JCS Pub Number 1)

Electronic Warfare Support Measures (ESM): That division of electronic warfare involving actions taken under direct control of an operational commander to search for, intercept, identify, and locate sources of radiated electromagnetic energy for the purpose of immediate threat recognition. (AFM 2-8)

Emission Control Orders: The selected and controlled use of electromagnetic, acoustic, or other emitters to optimize command and control capabilities while minimizing, for operations security, detection by enemy sensors; to minimize mutual interference among friendly systems; and/or to execute a military deception plan. (AFM 2-8)

Execution: Actions that carry out a declared intent such as an attack on a target. (JCS Pub Number 1)

Fire Control Radar: Radar used to provide target information inputs to a weapon fire control system.

Fire Support Coordination Line (FSCL): A line established by the appropriate ground commander to insure coordination of fire not under his control which may affect current tactical operations. The fire support coordination line is used to coordinate fires of air, ground, or sea weapon systems using any type of ammunition against surface targets. (JCS Pub Number 1)

Fire Support Element (FSE): Representatives that target and plan fire support and electronic warfare support.

Force Multiplier: Supporting and subsidiary means that significantly increase the relative combat strength of a force while actual force ratios remain constant. (JCS Pub Number 1)

Forward Line of Own Troops (FLOT): A line which indicates the most forward positions of friendly forces in any kind of military operation at a specific time. (JCS Pub number 1)

Immediate Air Support: Air support to meet specific requests which arise during the course of a battle and which by their nature cannot be planned in advance. (JCS Pub Number 1)

Interaction: Mutual or reciprocal action or influence.

Joint: Connotes activities, operations, organizations, etc., in which elements of more than one service of the same nation participate. (JCS Pub Number 1)

Joint Force: A general term applied to a force which is composed of significant elements of the Army, Navy, or Marine Corps, under a single commander authorized to exercise unified command or operational control over such joint forces. (JCS Pub Number 1)

Joint Suppression of Enemy Air Defenses (J-SEAD): That portion of SEAD which requires joint interaction to suppress enemy surface-to-air defense systems having an influence on the tactical air-land battle area. (TAC PAM 50-24)

Maximum Effective Range: The maximum distance at which a weapon may be expected to deliver its destructive charge with the accuracy specified to inflict prescribed damage. (JCS Pub Number 1)

Offensive Air Support (OAS): OAS is that part of tactical air support, conducted in direct support of land operations, that consists of tactical air reconnaissance (TAR), battlefield air interdiction, and close air support (CAS) which are conducted in direct support of land operations. (TAC PAM 50-24)

Offensive Counter Air (OCA): OCAs are those operations mounted to destroy, disrupt, or limit enemy air power as close to its source as possible. (TAC PAM 50-24)

Probability of Kill (Pk): A measure of the probability of destroying a target. (JCS Pub Number 1)

Roll Back: The process of progressive destruction and/or neutralization of the opposing defenses, starting at the periphery and working inward, to permit deeper penetration of succeeding defense positions. (JCS Pub Number 1)

Suppression of Enemy Air Defenses (SEAD): That activity which neutralizes, destroys, or temporarily degrades enemy air defense systems in a specific area by physical attack and/or electronic warfare. (Air Force Manual 2-8)

Target of Opportunity: A target visible to a surface or air sensor or observer which is within range of available weapons and against which fire has not been scheduled or requested. (JCS Pub Number 1)

Wild Weasel: Tactical fighter aircraft equipped with specialized warning and analysis receivers that detect and destroy hostile threat-associated, ground based emitters using antiradiation missiles and free-fall munitions.

ACRONYMS

AAA	Antiaircraft Artillery
AGM-65	Electro-optical Maverick
AGM-65D	Infrared Maverick
AI	Air Interdiction
ALARM	Air Launched Antiradiation Missile
ALR-69	Radar-Homing and Warning receiver
APR-38	F-4G Radar Receiving Set
ARM	Antiradiation Missile
CAS	Close Air Support
Comm Jam	Communications Jamming
EC	Electronic Combat
ECCM	Electronic Counter-Countermeasures
ECM	Electronic Countermeasures
EO	Electro-Optical
ESM	Electronic Warfare Support Measures
EW	Electronic Warfare
EWO	Electronic Warfare Officer
FEBA	Forward Edge of the Battle Area
FLOT	Forward Line of Own Troops
FSCL	Fire Support Coordination Line
GHz	Gigahertz
HARM	High Speed Antiradiation Missile
HUD	Heads Up Display
IR	Infrared
J-SEAD	Joint Suppression of Enemy Air Defenses
LGB	Laser Guided Bomb
MHz	Megahertz
Pk	Probability of Kill
RHAW	Radar Homing and Warning
RPV	Remotely Piloted Vehicle
RWR	Radar Warning Receiver
SAM	Surface-to-air Missile
SEAD	Suppression of Enemy Air Defenses
SOJ	Stand Off Jamming
TEL	Transporter Erector Launcher
TELAR	Transporter Erector Launcher and Radar
TOW	Tube launched Optically tracked Wire command
UHF	Ultra High Frequency
VHF	Very High Frequency
WW	Wild Weasel

AIRCRAFT REMAINING

ATTRITION RATE

DAY	1%	2%	5%	10%
0	1000	1000	1000	1000
1	980	960	902	810
2	960	922	814	656
3	940	886	736	531
4	922	851	664	430
5	904	817	599	348
6	886	785	541	282
7	868	754	488	229
8	850	724	441	185
9	833	696	398	149
10	817	668	359	121
11	801	642	324	98
12	785	616	293	79
13	769	592	264	64
14	753	568	238	55
15	738	546	215	42
16	724	524	194	34
17	710	504	175	28
18	696	484	158	22
19	682	465	142	18
20	668	447	128	14
21	654	429	116	12
22	641	412	104	10
23	629	396	94	8
24	617	380	85	6
25	605	365	77	4
26	593	351	67	3
27	581	337	61	3
28	569	323	55	2
29	557	311	49	2
30	545	299	45	1

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Headquarters Pacific Air Forces
PACAF/DO
Hickam AFB, HI 96853-5000

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USAFE/DO
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JEWC/J3
Kelley AFB, TX 78248-5000

Air Force Electronic Warfare Center
Electronic Warfare Section
Kelley AFB, TX 78243-5000

USAF Tactical Air Warfare Center
EC/ECEG
Eglin AFB, FL 32542-5000

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APO NY 09667-5000

37 Tactical Fighter Wing
37TFW/DO
George AFB, CA 92394-5000

3 Tactical Fighter Wing
3TFW/DO
APO San Francisco, CA 96274-5000

52 Tactical Fighter Wing
52TFW/DO
APO New York, NY 09123-5000

U.S. Army Air Defense Center
HHC
Fort Bliss, TX 79916-5000

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